Coincidence Prompt Gamma Ray Neutron Activation Analysis

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Phase 1 Progress Report

Phase 1 Objectives :

1. Determination of the prompt gamma-ray coincidence decay schemes of 10-12 candidate elements of interest including Sulfur, Carbon, Oxygen, and Nitrogen and the possible interfering elements present in their environments of interest, including those in coal and oil-bearing rock.;
2. Modification of the Monte Carlo code CEARPGA to include the prediction of coincidences responses from elements of known coincidence schemes and subsequent use of the code to predict measurement standard deviations of the elements of the elements of interest in their environments of interest.

Phase 1 Progress :

Feasibility studies have been performed using two NaI detectors (either two 5"*5" or one 5"*5" and one6"*6" detectors). Two neutron sources were used; a Cf-252 source and the prompt gamma ray thermal neutron beam of the NCSU PULSTAR nuclear reactor. The Cf-252 source was used with bulk samples while the neutron beam was used with small samples (mainly cylindrical samples ranging from 1" to 2" in diameter and 0.1" thickness). The elements that have been examined to date include; (1) Hydrogen, (2) Carbon, (3)Sulfur, (4) Oxygen, (5) Nitrogen, (6) Gadolinium, and (7) Nickel. Part of the progress made so far has been reported and is being published [1].

As expected the output signal in the coincidence spectrum was reduced. The lab experiments(using the Cf-252 source) gave better results than those from the reactor. The reason for that is the higher neutron flux in the reactor increases the probability of chance coincidences to occur. This greatly affects the coincidence spectrum and disturbs it.

Although the lab experiments on bulk materials gave better sensitivity than those from the reactor, it is still not sensitive enough to accurately determine the decay schemes of different elements or to obtain library spectra. For this reason, and to decrease chance coincidences, new electronic equipment has been ordered with another source of funding. The new equipment is the CAMAC data acquisition system (all the ordered components are listed at the end). This equipment will enable us to thoroughly analyze the pulse height spectra from both detectors, on-line or off-line. By doing that the corresponding coincidence events (with the required resolving time) can be determined. This new equipment has been previously used and proved to be useful [2].

As to the simulation part, the reactor experiment was successfully simulated using Monte Carlo techniques. Four different arrangements for the relative positions of the two detectors, the neutron beam, and the sample orientation were investigated. Also, the coincidence schemes of some elements were predicted. It is intended to pursue this area more and to predict the coincidence schemes of other elements of interest.

List of ordered electronic equipment :

1) CAMAC minicrate
2) SCM-301 SCSI CAMAC controller
3) ORTEC AD 413A four channel ADC
4) LeCroy 2367 ULM
5) LeCroy 4301 FERA driver
6) SCM 594 dataway display
7) PC computer
8) Kmax Software

References;

[1] Gardner, R.P. et al, "A Feasibility Study of a Coincidence Counting Approach for PGNAA Applications", 4th tropical meeting on Industrial Radiation and Radioisotope Measurement Applications, Oct. 3-7 1999, Raleigh, NC, USA.

[2] Vobecky, M. et al, "Multielement Instrumental Activation Analysis Based on Gamma-Gamma Coincidence Spectroscopy", Analytica Chimica Acta, 386 (1999) 181-189.